EFFECT OF NEOFAT ON OFFSPRING SEX RATIOS IN RAMBOUILLET AND SUFFOLK SHEEP

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SARAH ELIZABETH LANGE

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by

SARAH ELIZABETH LANGE

APPROVED:

Dr. Micheal W. Salisbury

Dr. Loree A. Branham

Dr. Gil R. Engdahl

Dr. Charles A. Pier

April 7, 2011

APPROVED:

Dr. Brian J. May
Dean of the College of Graduate Studies

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ABSTRACT

Maternal diet and body condition are conceivably the most studied factors influencing sex ratio. The objective of this study was to determine if Neo-fat® influences offspring sex ratio in Rambouillet and Suffolk sheep. Ewes were randomly assigned to one of two treatments (n = 46). Treatment 1 consisted of a basal diet to serve as a control, and Treatment 2 consisted of the basal diet plus Neo-Fat fed at 0.46% of body weight. Ewes were bred after four weeks of feeding and continued to be fed for an additional two weeks. Blood samples were taken at breeding to determine differences in NEFA concentrations in serum. Results were only considered for ewes lambing as a result of being bred on the first estrus cycle and indicated no differences among NEFA concentrations, lamb sex ratios or lamb birth weights ($P > 0.05$).

TABLE OF CONTENTS

Page

Acknowledgements iii

Abstract iv

Table of Contents v

List of Tables vi

Introduction 1

Literature Review 3

Objective 6

Materials and Methods 7

Statistical Analysis 10

Results 11

Conception Rates and Body Condition 11

Diets and Non-Esterified Fatty Acid Concentrations 12

Sex Ratios and Birth Weights 12

Discussion 15

Implications 16

Literature Cited 17

Vita 19

LIST OF TABLES

Page

Table 1. Nutrient compositions of the control Neo-fat diets fed to ewes on an as fed basis. 9

Table 2. Frequency of gender, birth weight oflambs and NEFA concentrations of ewes. 13

INTRODUCTION

The opportunity to control offspring sex in the breeding of livestock would be of tremendous significance to livestock producers. This applies to producers that are focused on producing a majority of one sex, such as show lamb producers, feedlot lamb producers and, to some extent, purebred ram producers. Show lamb producers are only able to sell male lambs for show at major livestock shows, therefore females are undesirable. Feedlot lamb producers would prefer to produce more males over females since males have been shown to have better feedlot gain. Many breeders and some scientists believe that sex is controllable, since certain factors controlled by man appear to determine sex. Maternal diet and body condition are conceivably the most studied factors influencing sex ratio. The term "sex ratio" refers to the number of males compared to the number of females that are produced in a group of 100 individuals. According to evolutionary theory, mothers should bias their birth sex ratios according to future reproductive benefits gained through their offspring (Trivers and Willard, 1973). In polygynous species where there are a small number of males, usually those that are larger and stronger are most reproductively successful (Trivers and Willard, 1973). Females in optimum condition should bias their offspring towards males, since they would provide the female with the highest return of genetic fitness due to their increased chance at passing on their genetics. Although this theory seems valid, research observations have not often confirmed this theory. Trivers and Willard (1973) made a huge advancement showing that individuals could be manipulated to adjust the offspring sex in response to environmental conditions, such as maternal nutrition. This sex-allocation hypothesis can be

successfully applied to ruminant species. There have been a limited number of controlled studies to determine whether maternal nutrition influences offspring sex ratio. This study will provide information on the effect Neo-Fat (Robt Morgan, Inc.) has on the gender of offspring born to Rambouillet and Suffolk sheep. Neo-Fat is a commercially available feed additive, high in polyunsaturated fatty acids, which has been shown to increase non-esterified fatty acid concentration in an animals' blood (Green et al., 2008). Information gained from this study will further knowledge about diet influencing offspring sex ratio.

LITERATURE REVIEW

Evolutionary theory suggests that females of mammalian polygynous species that are in better body condition should produce more male than female offspring (Trivers and Willard, 1973). Few controlled studies have been performed to either support or disprove this theory. However, a number of studies have demonstrated a significant variation from the anticipated 1:1 offspring sex ratio in mammalian species (Rosenfeld and Roberts, 2004). The lack of known mechanisms for sex allocation intensifies the problem of interpreting the results of allocation (Cameron, 2004). Many factors are thought to contribute to sex ratio, but maternal body condition and maternal nutrition are the most commonly observed. In their sex allocation theory, Trivers and Willard (1973) predicted that, in polygnous species where small groups of males fathered most offspring, females in better body condition would be expected to produce more sons than daughters. These sons would have a greater chance of passing on genetics and producing grandchildren. Whereas, females in poor body condition would be expected to produce more daughters, who would have a greater chance at passing on genetics than weaker sons would (Trivers and Willard, 1973). Although studies have attempted to prove this theory, the lack of a known mechanism makes it harder to interpret the results (Cameron, 2004).

The prediction that females in better body condition would bias their offspring to more males than females has been observed in several species of deer, Barbary sheep, domestic pigs and a number of other species (Rosenfeld and Roberts, 2004). It has been noticed in opossum that increasing the caloric intake of fats and oils before pregnancy can skew offspring sex towards males (Austad and Sunquist, 1986). In European badgers, it was

noticed that females in superior body condition implanted earlier and when the average implantation date was early, a male-biased cub group was produced (Dugdale et al., 2003). Cameron and others (1999) state that in the Kaimanawa horse population, a predominantly female foal crop was a result of mares in poor body condition at conception.

It has been observed that maternal body condition does seem to correlate to offspring sex ratio, but not as much has been studied about maternal diet in livestock. This could be due partly to the fact that the influence of dietary fat supplements on reproductive performance is not well understood (Staples et al., 1998). A study on mature mice found that mice fed a balanced ration very high in fat produced a significantly increased number of male offspring with a sex ratio that favored sons over daughters by almost 2:1 (Fountain et al., 2008). Ruminants become problematic when studying the effect of fats and oils on reproduction. One such problem is that the fatty acid content of certain fats is hard to determine. Typically, plant oils contain long chain polyunsaturated fatty acids (PUFA), while fats derived from animals contain mainly saturated fats (USDA, 2010). Another problem is that most fats are utilized by the rumen flora before making it to the small intestine. However, microbial biohydrogenation is not 100% efficient. Bauchart and others (1990) stated that approximately 25% of the consumed unsaturated fatty acids may be available for absorption in the small intestine to be delivered to tissues for metabolism.

It has been suggested that condition scores taken around the time of conception are more likely to support the Trivers-Willard theory than condition scores taken at other times during the reproductive cycle (Cameron, 2004). This suggests that sex ratio adjustment is most likely to occur around conception (Cameron, 2004). Matthews and others (2008)

attempted to find correlations between dietary measures over time, looking at increased nutrition at different times of pregnancy in humans. They found that nutrient intake in early pregnancy was not associated with fetal sex.

OBJECTIVE

1. To determine if Neo-Fat influences offspring sex ratio in sheep

MATERIALS AND METHODS

Thirty-eight mature Rambouillet ewes (*Ovis aries*) and fifty-five mature Suffolk ewes (*Ovis aries*) from the Angelo State University Management, Instruction and Research Center in San Angelo, TX were used. All procedures were approved by the Institutional Animal Care and Use Committee. Initial weight and body condition score was taken on all ewes at the beginning of the study, again when rams were introduced, and at the end of feeding 14 days after ram introduction. Ewes were randomly assigned into two treatment groups with up to fifty ewes per group. Treatment 1 consisted of a basal diet to serve as a control, and Treatment 2 consisted of the basal diet plus Neo-Fat fed at 0.46% of body weight, based on Green et al., 2008, in order for ewes to obtain 0.1kg/head/day (Table 1). Diets were balanced to be isocaloric and isonitrogenous, however following feed analysis the control diet was slightly higher in crude protein (Table 1). Ewes were put into pasture situation and were gathered and separated daily and fed treatment rations for four weeks before introduction of rams.

At the end of week four, ewes were then separated based on breed and put into separate pastures and continued to be separated and fed their assigned diet daily. At this time, Suffolk rams were introduced, one into each group of ewes. Marking harnesses were placed on the rams to indicate date of service. Records were kept daily to keep track of when ewes were bred. At time of daily feeding, all rams were separated and fed the control diet to eliminate any impact the Neo-fat would have on ram fertility. Ewes were fed for fourteen days after rams were introduced. Serum was taken at time of ram introduction to indicate the

impact of supplementation on metabolism. Serum levels measured included non-esterified fatty acids (NEFA).

Following day seventeen, ewes were comingled and put into a pasture situation ensuring similar diet selection until time for parturition. At that time, all non-pregnant ewes were exposed to clean-up rams. Any ewe that lambed as a result of clean-up rams, and her resulting lamb, was excluded from the study. At approximately day seventy-seven of pregnancy, all ewes were checked for pregnancy by ultrasound. Any non-pregnant ewes were removed from the study at that time. Approximately one week before parturition, ewes were brought to lambing facilities. At the time of parturition, lamb sex and birth weights were recorded.

Table 1. Nutrient composition of the control and Neo-fat[a] diets fed to ewes on as fed basis.

Nutrient, %	Control Diet	Neo-fat® Diet
Crude Protein	8.7	6.6
Crude Fat	3.5	6.6
Acid Detergent Fiber	36.4	41.5
Neutral Detergent Fiber	41.5	46.8
Total Digestible Nutrients	65.0	66.0

[a] Neo-fat (Robt Morgan, Inc) is a commercially available fat supplement that is high in poly-unsaturated fatty acids.

STATISTICAL ANALYSIS

Ewes were randomly assigned to treatments (n=46/treatment). Ewes were fed as a group and the individual ewe was the experimental unit. Ewe weight and lamb birth weights were analyzed as an analysis of variance and sex ratio was analyzed as a correlation between treatment and ratio. Data was analyzed using the GLM procedure of SAS (SAS Institute, Cary, NC). Treatments were considered different at $P \leq 0.05$.

RESULTS

Initially, fifty-five Suffolk ewes and thirty-eight Rambouillet ewes at the Angelo State University Management, Instruction, and Research Center were enrolled in this project (n=93). During the experiment, three ewes were removed for injuries, five were removed for non-pregnancy, four died from unknown causes and ten did not lamb as a result of breeding during the first cycle. Therefore, thirty-eight Suffolk ewes and thirty-three Rambouillet ewes were included in the analysis.

Conception Rates and Body Condition

Conception was calculated as the percentage of pregnant/exposed ewes. Of the eighty-seven ewes ultrasounded, eighty-two were bred successfully. This equates to a 94.6% conception rate overall, but only 81.7% in the first estrous cycle based on the date of parturition. According to Baker and Miller(1984), 80-85% of ewes should conceive during the first seventeen days of the breeding season under ideal breeding conditions. Therefore, the conception rate for the ewes in this study was normal. It was noted that all Rambouillet ewes were bred during the first estrous cycle. Although body condition scores were not statically analyzed, they were recorded. From the beginning of the study through breeding, all ewes were at approximately a condition three to four body score on a five point scale (Baker and Miller, 1984). At lambing, body condition for all ewes had dropped considerably to approximately two to three out of five. Body condition scores did not differ between ewes on control and treatment diets. Multiple ewes were affected by pregnancy toxemia, suggesting that maternal nutrition was not optimal to support multiple fetuses. It was also

noticed that ewes predicted via ultrasound to have multiples only produced one lamb. This could be due to ultrasound technician error or suggest maternal nutrition was inadequate to support multiple fetuses. This was more prominent in Rambouillet ewes than Suffolk ewes. It was also noted that Suffolk ewes seemed to begin lambing earlier than the Rambouillet ewes.

Diets and Non-Esterified Fatty Acid Concentrations

Diets in the two treatments differed mainly in % crude fat. Ewes in treatment 1 received a diet that was high in poly-unsaturated fatty acids. Treatment 2 diet, the control diet, contained approximately half as much crude fat (Table 1). It has been shown previously that a diet high in Neo-fat could increase blood concentrations of non-esterified fatty acids (Green et al., 2008). Blood samples were taken from forty ewes, twenty-one control and nineteen treatment, at introduction of rams to determine the concentration of non-esterified fatty acids. Table 2 displays frequency of gender, birth weight of lambs and NEFA concentrations of ewes for both diets. No difference ($P = 0.67$) was found in the concentrations of non-esterified fatty acids between treatment and control.

Sex Ratios and Birth Weights

According to Green et al. 2008, feeding an increased amount of fat could potentially skew offspring sex ratio in favor of males. All lambs, including those born dead, were taken into consideration. Although the actual number of female lambs was greater than the number

Table 2. Frequency of gender, birth weight of lambs and NEFA[a] concentrations of ewes.

	Neo-Fat Diet	Control Diet	SE	P Value
n	56	46		
Rams (head)	29.0	28.0	0.13	0.35
Ewes (head)	26.0	20.0	0.15	0.71
Body weight (lbs.)	10.22	9.82	0.42	0.48
NEFA concs. (mEq/L)	0.52	0.56	0.57	0.67

[a] NEFA = non-esterified fatty acid measured in serum at joining.

of male lambs born to ewes on the Neo-fat diet, there was no difference ($P = 0.35$) in offspring sex ratio between the two treatments. Additionally, neither diet caused skewing toward female lambs. Birth weights of individual lambs were diverse. However, when compared between treatments, there was no difference ($P = 0.48$). A variation in strength between lambs produced was observed, with some being visually a lot stronger than others. This could be due to the fact that ewe nutrition was not optimal during gestation, but the strength of lambs at birth was equal for both diets.

DISCUSSION

Using diets to alter sex ratio in livestock could be a useful management tool when the market or selection goals of an operation favor one sex over the other. Unfortunately, this has had little success as evidence by the current study. However, the results of this study are in direct contrast to studies such as Austad and Sunquist (1986) dealing with opossums and Fountain and others (2008) dealing with mice. Both of these studies showed that increased fat and oil intake would increase percentage of male offspring. Several factors could be playing a role in the difference between this study and those published in the literature. First, the other studies were looking at non-ruminant animals which could have an impact on absorption of the Neo-fat. Another possible reason could be the supplementation rate in relation to body size. Therefore, additional studies should be conducted to investigate the actual absorption and utilization of Neo-fat in a ruminant animal.

IMPLICATIONS

The results observed in this study indicate feeding an increased amount of poly-unsaturated fatty acids does not cause an increased percentage of male offspring, or increase birth weights.

Further studies feeding an increased level of poly-unsaturated fatty acids under optimal nutritional conditions may need to be examined. Increased supplementation may need to occur in order to prevent pregnancy toxemia in ewes and facilitate higher birth weights in lambs. This study could also be reexamined by additionally feeding rams a diet high in poly-unsaturated fatty acids to observe the effect.

As useful as this information could potentially be to certain livestock producers, it is still difficult to pinpoint the cause of sex determination in offspring.

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VITA

Originally from Norton, Texas, Sarah Lange is the daughter of Richard and Jean Lange. She attended Ballinger ISD and graduated from Ballinger High School in May 2005, where she was active in softball, choir and color guard. Sarah was also an active member of her local 4-H chapter, involving herself in projects such as food show, clothing and textiles and exhibiting lambs and goats. In the fall of 2005, she entered Angelo State University where she obtained her Bachelor of Science in Animal Science in May 2009. While working on her undergraduate degree, Sarah was a member of Block and Bridle. She also worked as a veterinary technician at a local vet clinic. Following graduation, Sarah began graduate school at Angelo State University to obtain her Master of Science in Animal Science with a focus in Reproductive Physiology. During both her undergraduate and graduate career, Sarah was a member of the Angelo State University Cattle Show Team, traveling across the country to various stock shows. As a second year graduate student, she obtained a graduate assistantship position. Sarah has enjoyed her career at Angelo State University and plans to pursue a career in the agriculture field.